Statement
of Mr. Daniel S. Goldin
Administrator
National Aeronautics and Space Administration

Before the Committee on Science

United States House of Representatives

April 28, 1999

Mr. Chairman, it is an honor for me to appear before your committee today to testify on this important issue -- that of mathematics, science, and technology education in our Nation's elementary and secondary schools and the role and responsibility of NASA in this important endeavor.

I would also like to note that shortly after being confirmed as the NASA Administrator in April 1992, my first official appearance before the Congress was to testify on the subject of NASA's Education Program. As I said then and repeat today, education is the single most important issue our generation faces today that will influence our Nation's course for the future. As the leader of NASA and someone who came from a family of educators, experienced the education of my own children, and now assists in fostering the education of my grandchildren, this subject is of utmost importance to me both personally and professionally.

Since the inception of the National Aeronautics and Space Administration in 1958, NASA and our Nation's education program have traveled parallel paths. We share the same goal -- that of exploration, discovery, and the pursuit of new knowledge and achievement of those goals is interdependent. NASA's success depends on the educational system to produce the highly skilled and knowledgeable workforce that is necessary to perform this cutting edge work. Likewise, the Nation's educational system looks to NASA for inspiration and to exemplify doing things that once were only imaginable -- feats that motivate and encourage our students to study science, mathematics, technology, and engineering. Future leaders of America, even if not astronauts, scientists, or engineers, must have a fundamental understanding of science, mathematics, and technology to reap the rewards of NASA's discoveries. Seven years ago I testified about NASA's national education effort. Today I would like to talk about how NASA's national education effort is comprised of 50 individual state efforts. Seven years ago I talked about our individual programs. Today I would like to describe how our individual programs reflect the educational agenda of the National Science Foundation (NSF), the Department of Education, national educational discipline associations, and others to assist in supporting the education agenda of individual states.

Over the past seven years, NASA has significantly improved its Education Program. The Program is comprehensive, reaching out to the elementary, secondary, and post-

secondary communities in all 50 states, the District of Columbia, and Puerto Rico. Our Program also targets those populations that are traditionally underserved in science, mathematics, technology, and engineering, especially through the Science, Engineering, Mathematics Aerospace Academy (SEMAA), the Summer High School Apprentice Research Program (SHARP), and the Historically Black Colleges and Universities (HBCUs)/Other Minority Universities (OMU) Program, which includes Hispanic Serving Institutions and Tribal Colleges and Universities. It is this comprehensive approach to education that allows NASA to tailor our support to the specific needs of the educational community. Today it is my pleasure to once again provide you a description of our efforts at the elementary and secondary levels.

WHY NASA INVOLVES THE EDUCATION COMMUNITY

Since becoming the NASA Administrator in 1992, I have spent much time with this Committee talking about NASA's accomplishments and our plans for the future. In the next twenty to thirty years, NASA has bold plans to unlock some of the mysteries of our universe. As you know, our mission is to answer fundamental questions of science and research, such as

- How did the universe, galaxies, stars, and planets form and evolve?
- Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on planet Earth?
- Are there Earth-like planets beyond our solar system?
- How can we use the vantage point of space to develop long-term, highly accurate models for natural disaster, weather and climate prediction?
- How can we revolutionize technology to make air and space travel for anyone, anytime, anywhere safer, more affordable, and have less impact on the environment and improve business opportunities and global security?
- And, how do we apply this knowledge to establish a permanent human presence in space to improve life on Earth?

However, to answer these questions, we will need revolutionary technology -- a new set of "tools for our future." It is our education system that will prepare our future workforce to design and use these "tools." Education is critical to NASA's future. Education is critical to the development of this revolutionary technology. Education is critical to the vitality of our Nation.

Let's take a moment to summarize some of these challenges to NASA and our Nation. For example, today it costs about $10,000 per pound for the Space Shuttle to take something to orbit -- about the same cost from a generation ago. For human missions to Mars, the current cost just to launch to low Earth orbit all the tools and materials needed to establish a permanent presence would be prohibitive. If we could cut that cost by a factor of 10-100, we could break open the space frontier for human exploration. The people to tackle this challenge are being educated in our Space Grant colleges and

universities today.

For a Life Finder Mission (terrestrial planet finder), we would like to station four telescopes about 400 million miles from Earth. The goal would be to find definitive proof of life on planets around other stars. We estimate the instruments on these telescopes will be ten times the size of Hubble. To accomplish this, we will have to develop a concave mirror that has the thickness of tissue paper. If we are successful, Life Finder will be able to detect molecules and gases -- those associated with the formation of life -- on planets orbiting other stars. Perhaps it will be some of our NASA Student Involvement Program sixth graders that will go on to develop these tools.

To improve weather prediction and extend our ability to predict the climate on a seasonal and annual basis, we will probably want to launch a telescope to another gravitational well between the Sun and the Earth. This telescope will be about five times larger than Hubble,

But it will also be cheaper, lighter, and have higher resolution. A similar telescope, one that can see at night just like soldiers do using infrared goggles, will look back at the dark side of the Earth. These two telescopes on opposite sides of the Earth will capture our planet's full sun-lit and dark-side images and will allow us to stare at the motions of storms, changes in ocean currents and plumes of volcanic ash. We will gain unbelievable images of the whole rotating Earth and an unbelievable array of new measurements 24- hours a day. Perhaps some of our GLOBE students of today will be the principal investigators for these telescopes of tomorrow.

In just about everything NASA does, we are looking to find biologically inspired solutions. Take the cockroach. Okay, maybe it's not the prettiest model. Its brain is much simpler than the human brain, yet it is able to operate a six-legged transporter mechanism; operate light and thermal sensors; operate gradient detectors such as a rapid change in light levels; deploy escape mechanisms; control a survival system (lays eggs before dying when poisoned); and has food search capabilities. We have almost no clue how to program such a complex device (and have it regenerate itself). However, development of this knowledge would undoubtedly open entirely new schemes for space exploration.

I've taken you through some of NASA's incredible challenges that are unbelievably tough. We will achieve many, but not all. However, what about some of our challenges as a Nation?

Think about health. Your primary doctor used to be the team captain of your family's health care program. She or he called in specialists when needed, directed laboratory tests, when appropriate and provided guidance in decision making. Today, and more so in the future, that is no longer the case. With the growth of managed health care, coupled with breakthroughs in biotech, biomed, genetic engineering, drug therapies, and medical devices; with prescriptions available on line, and with the resources of the Nation's medical libraries at your fingertips through the Internet, we often have to be, and need to be, our own health care captain. However, if we do not understand what the specialists are telling us, if we do not know how to measure the effectiveness of

alternative high tech therapies, or cannot decipher the meaning of sophisticated test results, then how can we expect to make smart health care decisions for ourselves and our families?

Next, think about environmental issues. Americans will soon be faced with important decisions regarding clean air and water, noise pollution, sustainable development, the use of pesticides, and natural resource management. The remedies are often explained in technological terms and the consequences couched in scientific jargon. If we are to make rational decisions regarding these issues, and help guide the political process in a useful way, we need to have at least some understanding of complex technologies that are typically based in physics, chemistry, and biology. Will we understand? As citizens, will our votes be rational or emotional? Will we be shaping the landscape of our children and grandchildren based on knowledge or guesswork?

Third, think about our national economy, which seems to become more dependent on technology every passing day. Look at the stock market and those high tech stocks. What is fad and what is not? How can you make intelligent investment decisions without understanding how technology is used and what will be needed in the years to come? Of course, how do new high tech companies grow unless they can find enough people who understand how technology is used and know how to use it? This issue is not limited to Silicon Valley. Did you know that the average family sedan today has more computer power than Apollo 11 did when it went to the moon? It is comparisons like these that remind me of the well-worn, but still accurate observation, that we sometimes get all the information, but refuse to get the message.

What are some of the workforce projections and demographics that may have an impact on these challenges? In about 30 years, women and minorities will comprise upwards of 70% of our Nation's workforce. Right now, 350,000 high-paying computer- related information technology (IT) jobs are vacant, leaving one in ten positions unfilled. There are just not enough skilled people to go around. If current trends continue, the shortfall in IT talent will grown to 1.6 million with several years.

Only 15 percent of engineering graduates in the U.S. are women, and only half of those go on to engineering careers. Hispanics make up just three percent of working engineers today, and African Americans barely 2.5 percent. Women make up only 20 percent of graduates in the physical sciences, such as chemists, Earth scientists, and computer scientists. The percentages for African Americans and Hispanics are even lower.

Engineering, computer science, and the physical sciences must be the domain of all of our society. We must realize the potential of technology. We must find the skills to turn promise into practical, useful reality. We must be concerned about the job market. After all, when people talk about improving their standard of living, having a clean environment, a safer place to work and live, and staying healthy longer, they usually mean the products or conditions brought about by science and engineering.

In universities, the issue is enrollment or, more precisely, the lack of enrollment. At the elementary and secondary school level, it is achievement, or more precisely, the lack of

it. In recent national-level testing, only 21% of our 8th graders -- boys and girls alike -- scored "proficient" in mathematics. Less than one in four grade school students take algebra. Fewer than half of all high school students take upper level mathematics or physic courses. Where do we go from here?

As I see it, we are rapidly approaching the day when the primary discriminator between the "haves" and the "have-nots" will be between those who understand technology and those who do not. It will not be age, sex, color, or culture -- it will be technology. It will be the ability to understand it and use it, as an engineer or scientist, or as a medical technician or sales clerk, or just about any other profession in the world. And that brings me back to what I said earlier. Education is critical to the development of revolutionary technology. Education is crucial to NASA's future. Education is critical to the vitality of our Nation.

NASA understands that we have to do our part to inspire and encourage every segment of our population -- girls and boys alike -- from every walk of life, every color and creed, to reach out and prepare for the opportunities of the 21st century.

WHAT IS NASA DOING TO INVOLVE THE EDUCATION COMMUNITY?

Early in my tenure as NASA Administrator, I had the opportunity to address a conference of scientists who were supported through NASA funding. During an interactive question and answer session, I learned that some of their research grants with NASA allowed them to retain exclusive rights to their data for a period of up to two years. I then asked with whom they communicated. Their answer was -- other scientists, of course!

I suggested to the group that NASA's role was to communicate the results of our research so that the average American could understand that NASA is an investment in our future, and to communicate those results in plain English. Furthermore, I suggested that each scientist in the audience should spend approximately one hour per week with young students, sharing with them the excitement of discovery. Just then, a participant stood and said, "Mr. Goldin, you just don't understand. We are too busy with our science. Why doesn't NASA pay for specialists to do this job for us?" They just did not understand that they work for the American people.

Much has changed at NASA since that eventful day. Today, information technology allows NASA to share our discoveries almost instantly with young people and the American public. Furthermore, it is everyone's responsibility, who is funded by hard-earned taxpayer dollars, to communicate knowledge in a meaningful way to our educational community.

Since its creation in 1958, NASA has made and continues to make significant contributions to the education community. As stated in the NASA Strategic Plan, our vision is that "NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand the frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth." In seeking this vision, NASA has identified five specific outcomes of our activities that contribute to the achievement of the Nation's

science and technology goals and priorities (a copy of NASA Strategic Plan 1998 is included for the record). Specifically cited is:

Educational Excellence: We involve the educational community in our endeavors to inspire America's students, create learning opportunities and enlighten inquisitive minds. (NASA Strategic Plan 1998)

It is this statement that provides overall guidance to our Education Program. First, in striving for educational excellence, only our customer, the educational community, can truly judge our performance. And second, the manner in which we strive for educational excellence is through both traditional and new and innovative methods to "involve the educational community in our endeavors."

In addition to our comprehensive, agency-wide educational efforts, the NASA Strategic Plan makes it the responsibility of each of our Strategic Enterprises to "embed" education into its program. No longer is it an acceptable practice to say, "we are too busy." Research, knowledge generation and education are all equal components of the NASA mission. We must combine our traditional methods of involving the education community with new and innovative ways so that the impact NASA has on education is greater. We need to find meaningful ways to involve students and teachers in our real, ongoing research programs. They need the opportunity to roll up their sleeves and practice science in order to learn about science, mathematics, and technology.

As you know, the NASA budget has declined over the past six years. However, during this same period, NASA has increased our overall investment in education through the Academic Programs budget line by approximately 52%, from $66M in FY 1992 to $100M in FY 1999. In addition, the Congressional process has annually increased total funding for Academic Programs in recent years, with an additional $38.4M appropriated in FY 1999. (Additional Congressional direction for education was placed in other parts of the NASA budget.) While our request for FY 2000 remains at $100M, and does not allow us to continue funding at FY 1999 Congressionally appropriated levels for some programs, it does allow us to continue providing a significant investment in our core, agency-wide education program and our minority university research and education program, and to provide the necessary infrastructure to maintain a viable agency effort. (Note: the NASA Enterprises contributed an additional $28.8M to our minority university research and education program in FY 1999.)

While this $100M investment in education over the past years has provided stability in our efforts, we are beginning to see the result of our policy to embed education into our research and development programs, thereby providing a significantly needed increase of NASA's total impact. While we are working on compiling these investments embedded in the Enterprise budgets, a first estimate puts that number at approximately $30M or higher, supporting activity at both the precollege and higher education levels. Over the next year, we will be able to more accurately report this number.

As important as the financial investment, we see an increased involvement with the educational community throughout our technical workforce, at our NASA Centers and through our efforts to take NASA out to all 50 states, the District of Columbia, and

Puerto Rico.

HOW DOES NASA INVOLVE THE EDUCATION COMMUNITY

NASA's education mission states: "NASA uses its unique resources to support educational excellence for all." But what makes NASA unique? What does NASA bring to the education table that other Federal agencies can't?

First and foremost, the NASA mission is unique and gives teachers and students an opportunity in which to participate and a visible, tangible example of using science and technology to achieve national goals. Whether it is exploring the surface of Mars through a robot named Sojourner on the Internet, witnessing the building of the most complex laboratory in space called the International Space Station, or providing ground truth data on rainfall and climatic conditions to researchers studying the Earth, students and their teachers become involved in the NASA mission, transferring their theoretical knowledge of mathematics, science, technology, and geography into its real life applications and integration to provide answers to questions.

Second, NASA's mission is carried out by people -- people from all walks of life, backgrounds, and educational levels. It is this human resource, representing approximately 18,000 NASA civil servants, our contractor community, and our university principal investigator community that provides role models, mentors, teachers, curriculum consultants, and volunteers to the K-12 education community. It's people like Lt. Commander John Herrington, NASA astronaut, working with students from the St. Regis Mohawk Nation on the importance of staying in school, studying mathematics and science, and setting goals. It's people like NASA Headquarters employee Linda Sampson, who volunteers her time with one of our Saturday Academies to help approximately 40 District of Columbia students learn about the importance of mathematics, science, and technology through space. And it's people like the 370 volunteers at the NASA Ames Research Center (ARC) where in 1998, they contributed nearly 10,000 hours serving as Docents for the Center. This program has enabled nearly all ARC education programs to serve many more educators, students, and the general public without sacrificing quality.

The third unique element that NASA brings to the table is our facilities, the laboratories where new planets are discovered, rocket engines are tested, the Shuttle and its payload are readied for flight, or where new models of the Earth and its interactive systems are visually studied. It is the 10 NASA Centers and their related facilities that provide a real life classroom to hundreds of thousands of teachers and students. Whether it is 250 high school juniors and seniors from throughout the country involved in an eight-week summer research apprenticeship with NASA principal investigators at all NASA Centers; 25 teachers participating in the engineering design process at the NASA Goddard Space Flight Center (GSFC) and translating that experience into student learning experiences; or the thousands of teachers and students that take a virtual tour of the International Space Station at the NASA Johnson Space Center (JSC) learning to use technology for exploring beyond their classroom, the NASA Centers provide a locale for experiencing the real world of inquiry and discovery.

NASA'S EDUCATION PROGRAM GUIDANCE SYSTEM

NASA is not an education agency. We look to others to establish the education agenda and seek to align our education program to support that agenda.

External Guidance

Over the past seven years, the Administration and its Federal interagency education groups have influenced NASA's Education Program, i.e., the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) and the National Science and Technology Council (NSTC). Specifically, the documents Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering and Technology Education, A Strategic Planning Document for Meeting the 21st Century, Science in the National Interest, and the National Science Policy Report Unlocking the Future: Toward a New Science Policy have provided overall guidance to Program policy and focus. Direct interaction with NSF and the Department of Education has provided additional focus, especially in Program coordination and alignment. Specifically, their emphasis on systemic change, high standards, quality instructional materials, and the use of technology in the learning environment are reflected in NASA's Education Program.

Likewise, the work of individual discipline-specific professional education associations and other science entities has guided our specific activities. These include, among others, the National Research Council (NRC), National Science Teachers Association (NSTA), National Council of Teachers of Mathematics (NCTM), American Association for the Advancement of Science's (AAAS) Project 2061, International Technology Education Association (ITEA), and the Geography Education National Implementation Project. The directions established by these discipline-specific education organizations provide guidance in translating the content derived by the NASA mission to reinforce the direction or agenda of each. Additionally, the understanding of each discipline's content (scope and sequence) and direction becomes a knowledge requisite for NASA education personnel staff development.

Finally, the third element of external guidance emanates from the state level. It is imperative for NASA to comprehend the state's agenda for education and to translate our unique capabilities, assets and programs to support that agenda when and where appropriate. To meet this requirement, we collaborate with organizations such as the Council of Chief State School Officers (CCSSO), the National Alliance of State Science and Mathematics Coalitions (NASSMC), and the Council of State Science Supervisors (CS3). Additionally, each NASA Center serves a specific geographical region for K-12 education to insure close collaboration between the states in that region and a specific NASA Center. Likewise, the National Space Grant College and Fellowship Program, a national network of over 700 public and private institutions nationwide, provides an in-state NASA asset that assists in NASA's collaboration with individual states.

Internal Guidance

The ability to translate external guidance into policy and program implementation requires an internal guidance system. Based on a study commissioned by NASA and

conducted by the NRC, the NASA Education and Program Evaluation Framework was established to serve as the model to guide the implementation and evolution of NASA's Education Program.

The NASA Education Program and Evaluation Framework provides a graphical representation of the NASA Education Program. It serves not only as a guidance tool, but also as an analytical mechanism to evaluate the comprehensiveness of our outreach to the education community. The framework depicts the integration of the three components of all NASA education programs, projects, and activities.

These three components are:

1. the content (based on the NASA Enterprises);
2. the customer (the formal and informal education community); and
3. the program category (the manner in which NASA education activities are provided to the customer).

The Content: The NASA Mission

The fundamental component of any NASA education activity is the content or knowledge derived from the NASA mission. At the Agency level, this knowledge is the outcome of the NASA mission as defined by the four Strategic Enterprises: Aero-Space Technology, Human Exploration and Development of Space, Earth Science, and Space Science. The knowledge derived from the NASA mission is the foundation for all of NASA's education activities. The role of NASA's Education Program is to add value by translating this content to meet our customers' needs.

The Customer NASA's education customer is the formal and informal education community. For the purpose of the framework, the formal education community is divided into the following levels based on grade: K-4, 5-8, 9-12, Community College, Undergraduate, Graduate, and Postdoctoral. At the K-12 levels, content (knowledge) derived from the NASA Strategic Enterprises is tailored to meet customer needs and is guided by curriculum standards for science, mathematics, technology, and geography at the national, state, and local levels. At the postsecondary levels, customers are directly involved in and support NASA's mission needs. The informal education community targets both the K-12 and postsecondary levels and includes science and technology centers, museums, planetariums, and other nonprofit education organizations.

The education customer is both the beginning and the ending point for all NASA education activities. It is the customer's education agenda that serves as the starting point in defining an educational project or activity. Furthermore, the education customer evaluates NASA's education activities to determine whether the Agency is contributing to education excellence.

Program Categories

Six categories comprise the NASA Education Program and define the way in which the

NASA content is delivered to the formal and informal education community. A summary of these six program categories, including examples for each, is provided in Appendix A.

EVALUATION OF NASA'S EDUCATION PROGRAM

In carrying out our mission, NASA strives to involve students and educators as both participants and partners. In conforming to the Federal Government Performance and Results Act of 1993, NASA is committed to evaluating the performance of our programs and activities in order to report to the Administration and Congress, and to provide for the continual improvement of our involvement of the educational community in our missions, research, development, and achievements. To that end, NASA is developing the NASA Education Evaluation System which includes an on-line, Internet based system for entry and collection of data from participants and program managers, third party evaluation of specific programs, and briefing and statistical presentation materials to be used for analysis and reporting. Education at NASA is an agency-wide endeavor with all education activity focused on and accounted for through our commonly accepted set of goals and objectives.

In FY 1998, the NASA Education Evaluation System was able to collect data on most of the agency-wide education programs, and many Center-specific programs and activities. The data summary below is a roll up of top-level measures that relate to the Education Program's two metrics -- excellence and involvement. The data are for FY 1998 and are in narrative form. Appendix B contains the data in chart format.

Excellence

NASA seeks to be judged by its customer, the education community, as providing excellent and valuable educational programs and services. Therefore, participants in NASA educational activities are asked a series of questions that are aimed at understanding our performance and the relevance of the activity to the participants. Participants may be teachers, K-12 students, higher education faculty, undergraduate/graduate students, educational administrators, etc. Feedback from participants are summarized in four categories, then averaged for an overall excellence rating. NASA attempts to maintain a customer excellence rating ranging between 4.3-5.0 (on a 5.0 scale). The following data are from FY 1998 participants (score 5 = excellent to 1 = very poor; total participants reporting 2,269 - 16,297; not all participants were asked all questions).

Recommend to others	4.70
Rate staff	4.59
Expect to apply what was learned	4.59
Valuable experience	4.73
Overall average for excellence	4.65

Involvement

NASA strives to involve the educational community in our endeavors. Therefore, at the proposed funding level, we want to maintain a level of participant involvement (in person) of approximately 3 million with the education community, including teachers, faculty, and students.

Progress towards this metric is measured in three ways: (1) total number of students/teachers/faculty involved in NASA education programs; (2) number of partnerships/collaborations with other institutions, industry, etc.; and (3) number of programs using NASA assets and types of assets used. The following FY 1998 data were collected:

Total involvement in NASA Education activities: 9,540,158 (151 programs reporting; based on actual participants and some estimates):

- In person: 3,018,244; electronic: 6,431,900; general public: 12,269,602 for a total involvement of 21,719,746
- 76% students; 5% teachers/faculty; 19% other (administrators/education professionals, parents, etc.)
- Students: 2,293,018; 52% K-4; 24% 5-8; 24% 9-12; 2% undergraduate; 0.4% graduate
- Educators/faculty: 140,355; 31% K-4; 44% 5-8; 25% 9-12; 1% community college; 2% undergraduate; 6% graduate

Types of K-12 schools represented (2,664 participants reporting):

- 39% urban; 37% suburban; 24% rural

NASA programs and external alliances:

- 6,096 instances of alliances
- Higher education institutions; industry; contractors; other NASA facilities; Educator Resource Center Network; non-profits; local community; school districts; State Departments of Education, etc.
- Ratio of programs with alliances to programs with no alliance, 2 to 1

Programs/activities using NASA facilities:

- 120 (note, some programs use multiple facilities): aircraft-28; ground trainers-14; laboratories-68; wind tunnels-20; VITS-video-19; computer labs-53; mockup facilities-24; auditoriums-48; classrooms-55

Additional NASA Program and Evaluation information and data are found in Appendix B.

THE NEXT FIVE YEARS

The NASA Implementation Plan for Education 1999-2003 outlines our agenda for the next five years (a copy is included for the record). We have identified (1) contributing to educational excellence, (2) developing alliances, and (3) involving the education community as the three leadership strategies that will guide our overall efforts. Seven specific improvement initiatives have been cited that outline our education agenda. These include:

- Focus and Coordinate Existing State-Based Efforts
- Enhance Instructional Products and Dissemination
- Improve Education Program Integration and Coordination
- Facilitate NASA Research in the Higher Education Community
- Support Preservice Education
- Target Informal Education
- Implement NASA's Comprehensive Data Collection and Evaluation System

Integral to the conduct of the NASA Education Program are the four operating principles of customer focus, collaboration, diversity, and evaluation.

One area of significant importance to NASA over the next five years is our commitment to increase our efforts in the informal education community. The increased symbiotic relationship developing between the formal and informal education communities requires us to bring our efforts with museums, science and technology centers, and similar nonprofit education organizations to the same level of organization and maturity that currently exists with our support of students, teachers, schools, and organizations in the formal education community.

CONCLUSION

Mr. Chairman, it has been my pleasure to testify before you and this Committee today, and to describe NASA's contribution to the K-12 educational community. Twenty to twenty-five years from now, when our children and grandchildren are the engineers, scientists, educators, doctors, business people, and visionaries that run this great country of ours, some of them might be working in the operations center to plunge a submarine underneath the icy ocean that we think covers Europa, one of Jupiter's moons. Others may be preparing for a visit to Mars. They will have the education and training. Because when they are in college, they will have learned to use the tools of our future and be prepared to answer the challenges of our Nation.

As one of our participant's commented in a six-month post workshop evaluation:

"The experience touched the Soul in each of us. I will go back to my school a changed teacher. I thought I had strived for the best in me when I was named Teacher of the

Year - but Space Camp made me reach beyond whatever I thought possible." -Vickie L. Boutiette, 1998 North Dakota Teacher of the Year

NASA's investment in education is indeed an investment in America's future. That's what we are about at NASA. Now let's get to work!

Appendix A

APPENDIX A

NASA'S EDUCATION PROGRAM CATEGORIES/GOALS/EXAMPLES

Student Programs

The National Science Education Standards and the American Association for the Advancement of Science's (AAAS) Project 2061 recommend that students learn science as inquiry. In this model, which is being implemented throughout the Nation, students are encouraged to "combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science" (National Research Council, 1996, p. 105). NASA's student programs reflect the science as inquiry standards by actively engaging students as they conduct science investigations, often at the side of a NASA mentor.

Goal: NASA uses its mission, facilities, human resources, and programs to provide information, experiences, and research opportunities for students at all levels to support the enhancement of knowledge and skills in the areas of science, mathematics, technology, and geography. NASA student programs (1) provide NASA mission experiences and information that are designed to promote students' interest and achievement in science, mathematics, technology, and geography; (2) provide exposure to NASA research and/or research experiences and activities to promote science, mathematics, technology, engineering, and geography career awareness; (3) provide support to the science and technology workforce pipeline by including greater participation of individuals who are underrepresented in science, mathematics, technology, and geography in NASA student programs; and (4) increase the number of NASA student support opportunities through partnerships and interagency cooperation and collaboration.

NASA student programs range from agency-wide national competitive programs, to Center-specific regional and state activities, to support of local school system career days and science fairs.

For example, NASA's nationally competitive Summer High School Apprentice Research Program (SHARP) involves primarily underrepresented minority high school students in intensive research apprenticeships with NASA, industry, and university scientists and engineers. The goal of the program is to involve students (approximately 500) in an eight-week research apprenticeship. The program is very competitive as only 23% of those who apply are accepted into the program and out of the almost 100% who go on to college, approximately 86% enroll in the disciplines of science, mathematics, or engineering. As a follow-on activity, the NASA Langley Research Center (LaRC) recruits high school graduates of the SHARP program and others into the Langley Aerospace Research Summer Scholars Program (LARSS). LARSS provides opportunities for SHARP graduates to continue with their pursuit of engineering and science degrees by providing summer internships at the Center during their undergraduate studies. Over 40% of the undergraduates participating in this program

have pursued graduate opportunities.

The Science, Engineering, Mathematics Aerospace Academy (SEMAA), begun in 1993, serves over 2,000 K-12 students with the primary goal to excite underserved students to an interest in science, mathematics and technology. SEMAA is managed by the NASA Glenn Research Center (GRC) through a grant with Cuyahoga Community College in Cleveland, OH. As a result of its success, SEMAA has been replicated in Detroit, MI; Dayton, OH; Chicago, IL; and Washington, DC with additional sites planned in Atlanta, GA; Baltimore, MD; Greenville, NC; Jamaica, NY; and St. Louis, MO. SEMAA's objectives are to demonstrate family-centered education practices and to foster collaboration with higher education faculties on the following: curriculum development; promotion of multicultural and gender equity; adherence to high mathematics and science standards; models of integration and application of advanced technology in K-12 educational settings; and to provide for systemic change through individual/ collaborative efforts with a range of partnerships.

The TexPREP program was started with NASA funds at the University of Texas San Antonio and over the years increased its impact on Hispanic Americans by adding over 27 college campuses throughout Texas. In 1997, NASA worked with the principal investigator for TexPREP to create a consortium to implement the program on Hispanic-Serving Institutions (HSI) campuses throughout the Nation. The program was renamed "Proyecto Access" to give it a national presence. The goal of Proyecto Access is to increase the number of socially and economically disadvantaged students pursuing academic studies and careers in mathematics, science, and engineering. The project conducts eight-week comprehensive summer programs, with a focus on mathematics, for middle school students at the eight HSI's. The program consists of college-level mathematics courses, mentoring, counseling, guest speakers on careers in mathematics, science and engineering, and field trips. This year it adds the Community College of Denver as its eighth project.

The NASA Glenn Research Center's New Approach to Student Achievement (N.A.S.A.) Project, is a six-week summer program held at Cuyahoga Community College's Metro Campus in Cleveland, OH for students completing grades 6, 7, and 8. The program focuses on average grade students who may not have an expressed interest in mathematics and science. Participants receive classroom instruction, conduct science projects applying mathematics and science concepts, develop proficiency testing strategies, and participate in computer classes, career counseling and field trips. The goal is to encourage these students to pursue a future in science, mathematics, and engineering. Unique to this program is a Saturday Parent/Student Workshop. Partnering with the National Technical Association and Youth Opportunities Unlimited, parents learn more about the African/African-American contribution to science and engineering, better understand child development, and discover new methods to control and create an environment supportive of his/her child's development.

The Mars Millennium Project, an example of a national multi-agency effort and a White House Millennium Council Youth Initiative, will encourage students to investigate the best of the past and present, and apply what they learn to design a community for 100 people arriving on Mars in the year 2030. The goal for each Mars Millennium team will

be to design a livable and life-sustaining community on Mars that is culturally and artistically rich. The project is being sponsored by NASA, the Department of Education, the National Endowment for the Arts, and the J. Paul Getty Trust. A host of public and private organizations along with some of the Nation's leading corporations and businesses are also taking part in the community effort.

Evaluation Data: During the 1998 Fiscal Year, NASA involved 2,293,018 students in our programs. Of those, 1,166,439 were from the Kindergarten to fourth grades; 541,298 from the fifth to eighth grades, and 525,484 from grades nine to twelve; 51,269 were undergraduates, and 8,528 were graduate students.

- Students reporting the focus of the activities in their programs indicated that 28% emphasized science; 24% emphasized technology; 23% emphasized engineering; 21% were focused on mathematics, and 4% other.
- Students reporting (sample size 566) indicated that their interest in science rose from 4.03 to 4.42 (on a scale of 1-5 with 5 being the highest) after the program; interest in technology rose from 3.52 to 4.26; interest in engineering rose from 3.27 to 3.98; and interest in mathematics rose from 3.93 to 4.16.

The career interests of reporting students after the program fell within the following categories (students could indicate all that applied):

Engineer	44%
Doctor	21%
Scientist	17%
Business	10%
Astronaut	7%
Teacher	6%
Lawyer	6%
Military	5%
Other or undecided	30%

Thirty percent of students in higher education indicated they would like to pursue a career at NASA, while 35% want to go into private industry, and 27% were interested in some kind of teaching.

Teacher Preparation and Enhancement Programs

As stated by the National Commission on Teaching and America's Future, "U.S. school systems provide too few teachers with the opportunity to fully master the subjects they teach and develop a range of teaching strategies that can reach all of their students". NASA provides both preservice and inservice teachers with opportunities to increase

the depth of their knowledge in NASA-related subjects and to learn new teaching strategies.

Goal: NASA uses its mission, facilities, human resources, and programs to involve educators and faculty to advance their knowledge and skills. We provide access to NASA information in science, mathematics, technology, engineering, and geography. These programs are designed to provide preservice and professional development experiences for K-12 educators. Educators (a) participate in NASA research and development activities, (b) apply methods for integrating these resources into their teaching, and (c) are informed about available NASA resources. NASA's teacher preparation and enhancement programs range from agency-wide, nationally competitive activities, to Center-based regional, state, and local activities, to in- school workshops in all 50 states, the District of Columbia, and Puerto Rico. The following provides illustrative examples.

Project NOVA is an example of an agency-wide national teacher preparation program. NOVA prepares highly literate preservice teachers in science, mathematics, and technology by creating change in higher education. The program disseminates nationally an undergraduate pre-service model based on high standards and benchmarks for science, mathematics, and technology, linking higher education faculty across several disciplines to create these models. To date, more than 100 colleges and universities have participated, involving over 4,000 students that will enter the future teaching profession.

The Augmented Learning Environment for Renewable Teaching (ALERT) Program is a partnership between two NASA Centers (NASA Ames Research Center [ARC] and the Jet Propulsion Laboratory [JPL]) and 10 campuses of the California State University (CSU) system, designed to improve Earth science education, and particularly Earth science preparation of future K-12 teachers. Campus teams of scientists and educators work with each other, their NASA counterparts, and NASA's remote sensing results to develop better tools, techniques, and courses on a wide range of Earth science topics. ALERT leverages existing programs such as the NASA Summer Faculty Fellowship Program for CSU professors, "release time" at the campuses, and close working relationships with related NASA Earth Science programs and teacher education programs.

As an example of an intensive agencywide program for practicing teachers, more than 500 educators participate annually in the NASA Education Workshops (NEW). These two-week workshops, held at NASA Centers during the summer, provide an opportunity for practicing teachers to update their background and skills in science, mathematics, and technology, translating this summer experience into classroom experiences for their students. The program is competitive - 29% of applicants are accepted. Thirty-eight percent of participants represent suburban schools, 34% urban, and 28% rural. On a rating scale of 5 (5=excellent; 1=very poor), participants rated "expect to apply what learned" at 4.76 and "valuable experience" at 4.73.

Evaluation Data: In FY 1998, NASA programs involved 126,961 K-12 teachers and 13,394 higher education faculty. (These numbers represent the total number of

identified teachers and faculty in all programs.) Data cited below are from the NASA Education Workshop program, representing approximately 1,100 K-12 teachers (5 being the highest).

	FY 97	FY 98
Rate the Staff	4.6	4.7
Recommend to Others	4.7	4.8
Expect to Apply What I Learned	4.8	4.8
Program Was a Valuable Experience	4.7	4.9
Average Rating	4.7	4.8

Educational Technology

As recommended in a recent President's Information Technology Advisory Committee report, Information Technology Research: Investing in Our Future, the U.S. should "accelerate and expand education in information technology." To contribute to that objective, we are developing innovative learning tools using technology. NASA's Classroom of the Future program, for example, has developed a 10-week instructional sequence on CD-ROM that allows students to manipulate and visualize images from some of our space-based observatories such as the Hubble Space Telescope.

Goal: NASA researches and develops products and services that facilitate the application of technology to enhance the educational process for formal and informal education. NASA's Educational Technology program supports two of the four components of the National Educational Technology Initiative - teacher training and excellent, engaging educational software. The Educational Technology program (1) produces technology-based teaching tools and strategies that are grounded in or derived from the NASA mission; (2) uses emerging technologies for, and applies existing technologies to, educational programs; (3) utilizes technology to facilitate communication within the educational community; (4) involves educators in NASA missions through innovative uses of technologies; and (5) conducts research into new teaching and learning practices that are made possible through NASA mission-derived technology. Our educational technology program and products are infused into our student, teacher, curriculum support and systemic change activities.

The NASA Classroom of the Future (COTF) continues to be a major component of our educational technology program. The role of the COTF is to translate NASA technologies and research results into learning tools, demonstrations, and teacher enhancement programs that support standards-based education. A premier example is a program called Astronomy Village, a ten-week course in astronomy for 9th and 10th graders. In Astronomy Village, students learn by becoming actively engaged in the scientific process. They conduct background research, collect and analyze telescope data, and present their findings just as real researchers would.

Another agency-wide effort, the Learning Technologies Program, provides demonstration projects and on-line systems dedicated to bringing NASA science to teachers and students in the classroom, using examples from NASA's unique missions. The goal of this program is to facilitate the use of technologies within the K-12 education systems. NASA, led by ARC, organizes various interactive on-line projects that connect classrooms with ongoing science and engineering work. The projects provide real and relevant content to enhance classroom curriculums. For example, the Wright Flyer Online, allows students to follow the testing of a full-sized replica of the 1903 Wright Flyer in a wind tunnel at ARC.

The Mars Virtual Exploration CD-ROM is an example of a technology based instructional product that has wide reach. Developed at ARC, this interactive, multimedia curriculum supplement features the people and technology used in the exploration of our nearest planetary neighbor. In March 1999, NASA granted exclusive worldwide rights to Modern School Supplies, Inc. (Hartford, CT) to manufacture and sell the Mars VE CD to schools and school districts to support the science curriculum.

In an innovative approach, combining the structured, ordered learning provided by textbooks with the dynamic, rich visual information found through the Internet, NASA is collaborating with the National Science Teachers Association (NSTA) and commercial textbook publishes on sciLINKS. NSTA places sciLINKS icons and codes in textbook margins at key subject areas. By accessing the sciLINKS web site and entering the code, students and teachers are guided to professionally selected web sites that support the particular science subject introduced in the text. The combination of these two diverse media has significant potential to bring the latest scientific discoveries to students within days.

NASA CONNECT is a series of 30 minute interactive instructional programs, developed by LaRC, delivered via television and the Internet, and easily integrated into local, regional, and statewide instructional technology initiatives. CONNECT links the everyday application of mathematics and science by NASA engineers and scientists, with students who, via the web, can interact with these professionals. Each program features students, a hands-on activity, and a lesson guide for educators and parents. The web component complements and extends the lesson; establishes a connection between the home and the classroom; and allows homebound and children schooled at home access to resources and programs.

Evaluation Data: Though it is still difficult to get absolutely discriminating data about World Wide Web activities, NASA Education activities can point to the following statistics for FY 1998:

Internet Hits	199,636,397
Giga Bytes of Data Transferred	28,379
Unique IP Addresses Identified	6,431,900

At least 72,500 participants were involved in NASA programs focused on educational technology, most of whom were teachers.

In addition, under the Executive Order 12999, Computers for Learning Program, NASA transferred the following information technology equipment to schools throughout the country:

Computers (number of CPUs transferred individually)	1,747
Systems (system consists of CPU, monitor, keyboard, and a mouse)	5,913
Types of ADP equipment (monitors, printers, other)	12,515
The original acquisition cost of all items transferred	$56,830,687

Curriculum Support and Dissemination

The Third International Mathematics and Science Survey indicated that textbooks used in the United States cover far too many topics in a shallow manner, not recognizing the higher order understanding demanded for excellent science achievement. NASA's mission provides content that has the depth and inherent excitement required to develop exemplary instructional supplements. As an example, the National Council of Teachers of Mathematics (NCTM) collaborated with us on the development of Mission Mathematics, a set of three grade-specific collections of NASA-based instructional activities that explore mathematical concepts in depth.

Goal: NASA develops, utilizes, and disseminates science, mathematics, technology, and geography instructional materials based on NASA's unique mission and results. Because education is primarily a state and local issue, we seek to broadly understand common curricula topics or standards, collaborate with outside education experts, and work with NASA Strategic Enterprise content experts to translate the NASA mission into supplementary instructional products. These products are derived from the mission activities conducted by the four NASA Strategic Enterprises. A comprehensive dissemination system has been developed to ensure that our customers have access to these products. The system is composed of (a) a physical presence in each state providing access to and training in the use of NASA's instructional products, (b) electronic networking resources, (c) integration of our instructional products into teacher/faculty workshops, and (d) partnerships with organizations involved in systemic education change. All of NASA's curriculum support products are provided to the U.S. Department of Education's Eisenhower National Clearinghouse.

An example of developing NASA materials to meet the specific need of Native Americans is the Salish Kootenai College (SKC) Teachers Ambassador program, a partnership between SKC and the Dryden Flight Research Center (DFRC) to develop culturally sensitive curriculum materials. In June 1998, SKC brought a group of Elders and Teacher Ambassadors to DFRC where they spent two weeks at the Dryden Educator Resource Center working with DFRC personnel to develop classroom materials that blend traditional Native American and modern scientific approaches to navigation, meteorology, and the environment. After a year of field testing, these materials will be published and distributed nationally as a NASA educational resource.

In collaboration with the NASA Centers, Educator Resource Centers (ERCs) have been

established at all NASA Centers and in 48 states, the District of Columbia, and Puerto Rico (two states pending), providing a distribution and inservice training location for all NASA educational materials (print and multi-media). This nationwide network is usually established at colleges/universities or state departments of education. NASA provides staff development and instructional materials to each ERC. Educators can copy any materials at no cost, providing their own blank tapes, computer disks, etc. In turn, the individual ERC assumes all associated costs for its operation. Additionally, the Central Operations Resource for Educators (CORE), a non-profit organization located at Lorraine County Vocational Center, Ohio, has been established for mail order distribution of NASA material.

As an example of a NASA Center-based ERC, JPL has been long-term partner with the Pomona Unified School District in the development of JPL's Educator Resource Center and its Applied Technology Classroom located at the Village at Indian Hill, a former shopping mall. Pomona is a large, multi-ethnic district east of Los Angeles and views NASA as a key mathematics, science, technology and geography team member. Teacher training workshops are already underway and the Educator Resource Room is set to open in June. Pomona Unified is planning to adopt the Applied Technology Classroom model into each of its junior high school science classrooms.

A key component of NASA's dissemination system is the NASA Education Homepage and Spacelink, an online repository of all NASA curriculum support materials and program information. Developed after extensive input from educators by the NASA Marshall Space Flight Center (MSFC), Spacelink also provides teachers with current information about the latest in NASA research and development. Established in 1988, Spacelink was one of the first online sites for educators and has been frequently cited for its excellence by educational organizations and publications.

Evaluation Data: In FY1998, 64 new titles were produced. Teachers rated NASA education products 4.8 on a scale of 1-5 with 5 being excellent. Teachers used these products as follows (based on 784 teachers responding; respondents could select all that apply):

Hand-on Activities	47%
Integrated into Existing Curricula	45%
Team Activities	35%
Lectures	30%
Critical Thinking Activities	26%
Group Discussions	25%
Interdisciplinary Activities	18%
Science & Mathematics Standards Integration	16%

Demonstrations	15%
Background Information	4%

During FY 1998, Educational Resource Centers, located throughout the country, distributed the following educational materials:

Educational Publications	873,920
Video Tapes with Video Resource Guides	23,745
Video Tapes	53,189
Slide Sets with Scripts	6,264
Slides	8,570
CD-ROMS	3.323
Software Reproduction	4,846
Hits to ERC Web Page	83,451
Other NASA Non-technical info. publications	309,538

Research and Development

Research and development activities occur primarily, though not exclusively, at the graduate level and involve graduate students and faculty who make substantive contributions to NASA's mission, the four Strategic Enterprises, and the "Generate Knowledge" process. In addition to directly supporting NASA programs, these activities promote the development of new collaborations with the academic community and significantly enrich graduate education and research. Although information about these programs at the higher education level is not included in this testimony, they are an important component of the NASA Education Program framework.

As we seek new and innovative methods to involve the K-12 community in our mission, one area in which we are expanding is through opportunities for precollege educators to participate in research and development activities. Embedded in our research program, one such example at the K-12 level is a three-component flight opportunity program for students being developed at GSFC. One component is an on-board the Shuttle research design that flies in the ballast canisters. A second component is a sounding rocket program that allows students to design, develop, and launch an experiment at the Wallops Flight Facility, and then analyze the results. The third is a balloon-based program that can be launched at the individual school. All of these programs focus on developing student research skills at all levels. Even kindergarten students have flown experiments.

The GLOBE Program consists of a worldwide network of primary and secondary school students who work under the guidance of GLOBE-trained teachers to make

environmental observations at or near their schools, report their data to a GLOBE student data archive, receive and use global images created from the data they and other students have collected, and study environmental topics in their classrooms. GLOBE environmental measurements relate to the following study areas: atmosphere; hydrology; land cover/biology; and soils. The data acquired by students are used worldwide by environmental scientists in their research to improve our understanding of the global environment. GLOBE is managed by an interagency team that includes NASA, the National Oceanic and Atmospheric Administration (NOAA), NSF, the Environmental Protection Agency, and the Departments of Education and State.

An independent evaluation of the GLOBE Program indicates that when GLOBE and non-GLOBE students' performances in Earth science content areas in which they both received some instruction were compared, GLOBE students out- performed non-GLOBE students by 53% versus 36% for knowledge of measurement procedures, 56% versus 51% for sampling and measurement principles, and 48% versus 42% for interpreting data and applying concepts. GLOBE students also have a fuller appreciation of what it means to be a scientist and are more interested in pursuing a career in science. In the minds of active GLOBE teachers, the biggest impacts of the program on student learning are in the areas of observational skills, measurement skills, and technology skills. Roughly half of these teachers think GLOBE has very much improved students' abilities to understand data and to work in small groups. Smaller but still significant proportions reported major improvements in critical thinking and map skills.

Support for Systemic Improvement of Education

The challenge of improving state education systems requires collaborative approaches involving multiple agencies all oriented to the achievement of high standards. NASA, through programs like CNEC, the Connecticut NASA Education Collaboration, and through work with the NSF, Council of State Science Supervisors, the Council of Chief State School Officers, and NASSMC, is working to bring its multiple assets to bare in a state in order to support that state's agenda in education.

NASA uses its unique assets to support local, state, regional, and national science, mathematics, technology, engineering, and geography education efforts through collaboration with internal and external stakeholders. As the United States continues to reform science, mathematics, technology, and geography instruction in its K-12 schools, NASA has placed emphasis on coordinating all of the NASA assets in a given state toward assisting in meeting its goals for improvement of the state's system of education. By establishing a variety of partnerships, NASA seeks to convene NASA principal investigators, NASA-trained teachers, and other educational assets, and NASA commercial contractors with the state's education leadership to determine how these assets may best be utilized within the state. These activities are designed to: (1) coordinate planning among NASA education initiatives to ensure alignment with and support of systemic improvement initiatives of the states; (2) redirect existing education programs, and ensure new initiatives address state needs and tie unique education and economic development efforts; (3) support standards-based science, mathematics, technology, and geography education change by aligning NASA educational programs

and products with the state standards; and (4) expand interactions with external stakeholders in the systemic improvement of education change.

A major program in support of systemic change at the elementary and secondary education level is the Aerospace Education Services Program (AESP). AESP's Aerospace Education Specialists (approximately 40) have broad in-depth knowledge of NASA missions and programs and strong content background in NASA's four Strategic Enterprises. They are experienced professional educators, current on vital education issues and familiar with the curriculum frameworks and systemic architecture of the states they serve. Specialists are actively involved in state systemic improvement and education reform efforts. AESP personnel are knowledgeable on the full range of NASA's curriculum products, its diverse resources for students and teachers, and its extensive array of education projects throughout the country. AESP serves as one NASA focus for facilitating this objective. In FY 1998, AESP Specialists conducted over 1,700 workshops in all 50 states, DC, and Puerto Rico, involving more than 19,000 teachers. NASA is committed to coordinating all of its assets in each state in order to assist state and local leadership in meeting goals for systemic improvement.

Linking Leaders, initiated in 1996, has supported NASA's education implementation plan to connect its educational efforts to the systemic change work occurring at the state level and to enhance the work of the states by aligning NASA programs and resources with state education change efforts. The project has revealed and underscored the complementary agendas, the overlapping constituencies, and the power of the NASA/National Alliance of State Science and Math Coalitions (NASSMC) partnership in catalyzing and focusing mathematics, science, and technology education change efforts at the state level. Over the past three years, NASSMC, working in cooperation with NASA, has piloted the use of a client-centered model to achieve three goals using leadership teams from Alabama (MSFC), Colorado (JSC), Florida (KSC), Mississippi (SSC), Ohio (GRC), and Washington (ARC):

- to reach an understanding of key state educational reform ideas such as standards and statewide systemic improvement;
- to identify key elements of systemic improvement in each state that need greater attention; and
- to identify ways for NASA and its assets to better use their existing resources to impact statewide systemic improvement.

Using Florida as an example, Linking Leaders brought together a group of leaders drawn from NASA's Kennedy Space Center, aerospace and technology corporations, K-12 education and state policymakers. Since its first meeting less than eight months ago, the group has established and implemented an action plan in support of Florida's agenda for the continuous improvement of mathematics, science, and technology education. Specifically the Linking Leaders group has:

- conducted, at the request of the Florida Department of Education, a statewide survey of science teaching in grades K-8;

- undertaken, at the request of the Florida Standards Commission, revision of the Content Standards for Teachers in the areas of mathematics and science;
- assisted state policymakers in framing, and achieving passage of legislation that establishes statewide testing of science in grade 8;
- assisted state policymakers in framing, and achieving passage of, legislation that establishes and funds statewide professional development programs in mathematics and science for teachers of grades K-12;
- been invited by the State Commission of Education to guide the implementation of the new professional development legislation; and
- established the Florida Coalition for the Improvement of Mathematics and Science (CIMS) to expand and sustain the work of Linking Leaders in Florida.

A similar effort initiated through Linking Leaders is currently underway in the State of Alabama in cooperation with the Marshall Space Flight Center (MSFC). The business community, state education personnel, state policy makers, and NASA affiliates such as the Alabama Space Grant Consortium have formed the Alabama Mathematics Science and Education Technology Coalition to improve science, mathematics, and technology education in Alabama.

Another example of supporting systemic change is GSFC's work with its states in the northeast. As an example, GSFC and the State Departments of Education in Connecticut and Maine are working together to support teacher and curriculum reform efforts. These collaborations link NASA with the formal and informal education networks of schools, museums, and science centers as part of their state systemic initiatives. For example, the Connecticut/NASA Education Collaborative (CNEC) is a partnership among leading state educational institutions, informal education science centers, mathematics, science and technology teacher organizations, and the Connecticut State Department of Education.

The goals of this effort are to:

- collaborate with school districts, NASA's business partners, colleges and universities, informal science centers, and other educational service providers in an effort to improve science, mathematics, and technology education;
- develop awareness of NASA's educational efforts as they relate to Connecticut's systemic reform initiatives and state curriculum frameworks;
- create a system of NASA Training Sites and support a NASA ERC for the dissemination and training of appropriate NASA curriculum and programs;
- coordinate and develop a unified plan to involve, inform, and unite the business community, NASA and non-NASA related, to facilitate science, mathematics, and technology education throughout the state; and

- develop career opportunities for Connecticut's student population.

As part of this effort, 24 workshops for Connecticut teachers throughout the state are being conducted this year.

THE NASA ENTERPRISES: EXPANDING OUR REACH AND IMPACT

While the content and knowledge derived from the NASA Enterprises is the underpinning or foundation of NASA's Education Program, it is within each Enterprise that we have the opportunity to expand our support to the education community through embedded educational activity. Each Enterprise represents a subset of the NASA program, having its own set of associated industries, university principal investigators, and the public. Our ability to further engage each Enterprise community toward contributing to the whole of NASA's Education Program provides an opportunity to increase the scale and impact of NASA's investment in education.

Aero-Space Technology Enterprise

The Aero-Space Technology (AST) Enterprise is working to make the application of mathematics, science, and technology exciting and relevant to students by highlighting how working scientists and engineers use these tools in their research. Using AST programs and projects as the subject matter, products are developed using high standards and providing lesson guides for educators to easily understand and incorporate these materials into their classroom curriculum.

The Aero-Space Technology Enterprise is also very concerned about the need for mathematics, science and technology competencies of elementary and middle school students so that they will have the skills needed that allow them technical options in their career choices. The Enterprise is interested in raising student awareness of careers requiring mathematics, science, and technology and overcoming stereotyped views of engineering by presenting materials on exciting technical careers that include women and minorities as role models. The Enterprise provides support for educational conferences and events, and has recently produced the career poster "Superstars of Modern Aeronautics," highlighting 12 diverse individuals and their technical contributions, what motivated them to pursue engineering, and their personal advice to students. This poster is the third in a popular series titled, "Your Attitude Determines Your Altitude."

Specific examples of the AST Enterprise contributions to NASA's Education Program follow:

Teacher Enhancement: As an example of an embedded education program, the Pathfinder team, in conjunction with its record setting altitude flights in Hawaii, held teacher workshops on the islands of Kauai, Maui, and Oahu, reaching more than 200 underserved teachers from 20 different schools. NASA's education and research teams brought to the state an education program they developed, using Pathfinder as a context for teaching science, mathematics, and technology. At the Pacific Missile Range Facility, 1,000 students and teachers attended an Open House to dedicate Pathfinder's altitude records to the children of Hawaii and Colonel Ellison Onizuka.

Curriculum Support: Flight Testing Newton's Laws uses aircraft to stimulate the student's interest in the physical sciences and mathematics. For grades 9-12, this instructional product emphasizes how Newton's three laws of motion apply to flight testing an aircraft. Instruction is highlighted with videos, and was produced in partnership with the National Test Pilot School, to demonstrate physical concepts.

Education Technology: NASA's Mobile Aeronautics Education Laboratory (MAEL) offers educators across the U.S. a unique opportunity to explore how technology can be used as a tool to transform learning. The MAEL shows students and teachers a "classroom of tomorrow" where visitors explore different technologies through a curriculum that builds on NASA's success in aeronautics. The 53-foot trailer travels six months a year to various partnership cities. The MAEL program seeks to model a collaborative approach to education, and by traveling to and tapping into the community resources of each host city, assists stakeholders in exploring the potential of technology- assisted classrooms.

Earth Science Enterprise

The NASA Earth Science Enterprise (ESE) is at the forefront of the international scientific endeavor to understand our changing planet. ESE research missions provide not only the latest scientific understanding of the Earth, but provide many exciting educational applications and resources as well. The ESE has embraced its responsibility to disseminate information about the Earth system through education and public outreach. Opportunities for education and student involvement are embedded in a variety of ESE missions and programs. The ESE Graduate Fellowships which encourage and train the next generation of researchers, and the inclusion of education as a critical component in the planning and selection of new missions such as Triana and the University Earth System Science Earth Probe Program are just a few examples of how ESE incorporating education into its research and flight programs. The ESE has also has a well established Education program which has worked to establish a focused, sustainable ESE education strategy which delivers Earth Science content within the context of the NASA Education framework, agencywide. The ESE education strategy lays out the principles, goals and objectives for the program.

While the ESE education program has initiatives in each of the program areas outlined in the NASA Education Framework, one of the unique strengths of this program are the innovations that have been instituted to assure high quality products and programs and the best allocation of available resources. Education grants funded by the ESE education program are selected based on the results of a formal peer review process, which includes representatives of both the scientific, and education communities. This process, similar to the review process used for scientific research grants, has established an equitable process for the evaluation and selection of proposals for funding. In the area of curriculum support and dissemination, ESE established an annual external review of Earth science education products. Both scientists and educators review the products, and the results are used by ESE to determine which materials will be reproduced and made widely available to educators. These materials are distributed through workshops, training programs, the NASA Educator Resource Centers, and the other NASA distribution systems.

Some specific examples of the ESE Enterprise contribution to NASA's Education Program follow:

Educational Technology: NASA's Classroom of the Future has developed a 16 week on-line Earth system science course (K-4, 5-8, 9-12) to provide pre-service and in-service educators with a flexible means of obtaining graduate credit in the study of Earth as a system and develop practical curriculum support materials for classroom use. This is a web-based initiative utilizing problem-based modules to address authentic worldwide environmental dilemmas and inform students of the supplemental Earth Systems Science curriculum materials developed by NASA ESE, and other Federal projects.

Curriculum Support/Dissemination: NASA's ESE has over 60 different products and resources available in print and electronic media which have been reviewed through an external, peer review process. This material is available through the NASA Education Resource Centers, NASA CORE, the NASA Aerospace Education Services Program, Teacher/Faculty Enhancement programs and local regional and national conferences and conventions.

The Earth Science Enterprise provides training to members of NASA's Educators Resource Center Network and the Aerospace Education Services Program on peer reviewed Earth System science products. Participants commit to conduct a minimum of three ESE education workshops for local educators during the following year. This has resulted in approximately 20,000 teachers across the nation having received training on Earth System science topics and products.

Human Exploration and Development of Space Enterprise

The challenges and opportunities of human exploration beyond Earth will be one of the defining elements of human society in the next century. The efforts of human space exploration will expand the intellectual and technological resources of our civilization, and will enable us to better understand our place in the Universe. During the past four decades, ambitious human space flight missions have inspired generations of young people to undertake careers in the sciences and in engineering, benefiting both themselves and society.

The HEDS Enterprise is all about life on Earth. As HEDS expands the frontiers of space and knowledge by exploring, using, and enabling the development of space for human enterprise, it also continues to create a sense of wonderment in American students.

For the Office of Space Flight, education projects such as EarthKam, and SAREX, directly involve students in Shuttle Flights. EarthKam is a bold educational experiment. Put a camera on the Shuttle, point it at Earth, and let students use it to investigate Earth from space. The program links middle, high school, and university students to Space Shuttle missions. With direct and exclusive access to their own digital camera on the Space Shuttle, students can conduct scientific inquiry in support of their middle school Earth science studies. Space Flight will continue to create a wonderment and excitement in students in the future through educational programs conducted through the Space Station.

A NASA Kennedy Space Center (KSC)/JSC/ARC team developed and operates an online project called Shuttle Team Online (STO). This project focuses on the people behind-the-scenes who make the Shuttle fly, and uses the Internet to connect primarily K-12 students with NASA's exciting Shuttle team. The purpose of STO is to provide students real life examples of using mathematics, science, and technology while demonstrating the variety of skills and educational backgrounds required to make the Shuttle program fly.

Space Flight has recently initiated the Window On the Universe (WotU) Program. This initiative will establish a national network of 15 underserved communities committed to sustainable community-wide science, mathematics and technology education. WotU will use human space flight and the space sciences, within a multidisciplinary and cross-curricular context, to engage entire communities, facilitating sustainable intra-community linkages between school districts; museums, science centers, and planetaria; K-12 educators, local area researchers and amateur astronomers, business and civic organizations, and the public at large. Strong emphasis will be placed on facilitating family learning, with extensive participation by mothers, as well as groups traditionally underrepresented in science and technology fields.

NASA's Office of Life Sciences and Microgravity Science and Applications supports a variety of activities specifically focused on the needs and interests of the nation's educators and students.

For example, at JSC we are developing a series of middle school technology products that include educator guides, student worksheets, hands-on activities, and video resources, focusing on areas of JSC expertise. Titles in development include: Eating and Drinking in Space, Hygiene in Space, Pre-Breathing, and Waste Management in Space. The currently completed title is Recycling in Space. The project will include CD-ROM materials for student use and an interactive web site. This group has previously produced 'virtual' electronic tours of specific Life Sciences facilities, such as the Neurolab Virtual Tour, which was released on the internet in 1998 prior to the launch of STS-90 (Neurolab), and is also available on cross-platform CD-ROM.

In the Life Sciences arena, the STELLAR Program at NASA Ames Research Center (ARC) offers K-12 teachers a unique opportunity to experience science in the laboratory setting. It is a "hands-on" science training program for teachers interested in improving their knowledge and skills in science, math and technology. The STELLAR program brought 20 teachers and 30 Associates to ARC last summer. Teachers spent 5 weeks at ARC with half of their time spent in labs as researchers and the other half developing classroom lessons. They committed to a yearlong association with NASA, beta testing the summer lessons until they were finalized and released on the Internet. An 8- week program for high school students matched with a STELLAR teacher and a space biology discipline expert developed a CD-ROM multimedia learning tool.

A SpaceLife ExPress for young readers at K-4 and 5-8 reading levels was created. The first three issues focused on Space Biology and missions such as Neurolab and John Glenn's return to space on STS-95. Future curricula will be adapted for the Internet.

The Microgravity Science program has produced a teachers' guide for grades 5-8 and 9-12, with activities in science, mathematics, and technology. More specifically it produced "Connect-Microgravity: Doing More in Less," one of four live educational programs for PBS stations in Alabama, Kentucky, Ohio, South Carolina, and Virginia and other American viewers through the StarNET system. This program was selected for the 1998 Aurora Gold Award in instructional and science education.

A science activity kit, "Destination: Mars!" was created in partnership with Lockheed-Martin, and the Boston Children's Museum. It is available to classrooms and other student groups (clubs, scouts, science fairs, etc.) focused on the Life Sciences topic, life support and bioregenerative techniques.

The Space Life Sciences Training Program has, for 14 years, brought the brightest and most diverse undergraduates to KSC for a 5 week summer internship in research. Typically the 40 students select one of four sciences 'streams', producing a 'thesis' at the conclusion of the summer.

This year the KC-135 research program for undergraduates was expanded to include students from Texas community colleges and high schools. There will be a total of 96 different schools and universities represented, with undergraduates from almost every state submitting proposals for experiments.

Space Science Enterprise

The Office of Space Science has embedded education and public outreach (E/PO) into all its flight missions and research programs. Starting in 1997, every new flight mission has been required to have a funded E/PO as an integral element of the program. Proposals submitted in response to Announcements of Opportunity for participation in new missions must contain an E/PO component that is peer- reviewed. The results of those reviews are considered as part of the selection process. Similarly, E/PO is included in all OSS Research Announcements and scientists are strongly encouraged to submit E/PO components along with their research proposals. As a direct result of these new policies, last year, more than 20% of the research proposals submitted to OSS contained an E/PO component. Several dozen of these E/PO activities have now been funded and are underway. Initial results will be reported next fall. Guest Observers on major Facilities such as the Hubble Space Telescope are also encouraged to submit E/PO proposals along with their requests for observing time. This policy was put into place beginning with the Cycle 8 call for HST observing proposals and E/PO awards to 22 Guest Observers/Archival Researchers have just been made. E/PO awards were also made in conjunction with the selection of the first set of Chandra Guest Observers.

As a consequence of these and other actions, OSS is now in the process of assembling a broad portfolio of many types of E/PO activities being carried out in a wide variety of institutions and communities across the country. For example, over the past several years the "Solar System Science Ambassadors" program, being carried through several of the Solar System Exploration mission at JPL, has competitively selected 84 Master Teachers who have received extensive training and have, in turn, presented workshops to thousands of other teachers in more than 20 states. JPL has also consulted

extensively with the Adler Planetarium concerning their new exhibit on the planets. The HST Science Institute has established an extensive E/PO program. Educational materials produced by the Institute are readily available to teachers everywhere and are being used widely. Many of these are accessible through the Internet. The Institute has also been working with the Smithsonian Institution Traveling Exhibition Service to develop a major exhibit on HST. The exhibit will open in October. During its planned 3-4 year tour, several million people are expected to see it. The Structure of the Universe Education Forum together with the Chandra education group have been working with the Boston Museum of Science on a new planetarium show "Journey to the Edge of Space and Time" that will open next month. This show, like many others now being developed with OSS support, will be available in multiple formats and is intended for national distribution.

This list only provides a small sample of the activities that are now underway. OSS intends to make the results of its E/PO programs national resources available to educators everywhere. To achieve this objective, OSS is now in the process of creating an on-line Resource Directory that will provide information on and ready access to the best space science E/PO materials and products. This activity is being carried out in conjunction with the NASA Education Division and the Department of Education's Eisenhower National Clearinghouse. OSS is also now assembling a comprehensive Report summarizing all of its education activities. The first versions of both the Report and the Resource Directory will be available by the end of 1999.

The Office of Space Science (OSS) has established an education and public outreach "Ecosystem," which will serve as a network for OSS, fostering a wide variety of highly leveraged education and public outreach activities that will be disseminated across the country. Key elements of the "Ecosystem" include the establishment of four education Forums and five regional Broker/Facilitators.

The Forums will serve as major centers for space science education and public outreach in each of the four OSS science themes. They will orchestrate and organize in a comprehensive way, the education and public outreach aspects of OSS missions and research programs, and provide ready access to relevant education and public outreach programs to both the space science and formal/informal education communities.

The Broker/Facilitators will work with the space science community to identify high-leverage opportunities for education and public outreach and help arrange collaborations between scientists and educators.

The NASA Strategic Plan mandates that we "involve the education community in our endeavors to inspire America's students, create learning opportunities, enlighten inquisitive minds", and "communicate widely the content, relevancy, and excitement of NASA's missions and discoveries to inspire and to increase understanding and the broad application of science and technology." OSS has an extraordinary potential for contributing to these goals, such as helping to ensure that a continuing supply of scientists, engineers, and technologists will be available to meet the needs of the twenty-first century. Discoveries by our missions and research programs have engaged people's imaginations, informed teachers, and excited students and the public about

science and exploration. To further realize this potential, OSS has made education at all levels and the enhanced public understanding of science an integral element of the Space Science Strategic Plan. Specifically OSS will:

- Have a substantial education and outreach program associated with every space science flight mission and research program.
- Increase the fraction of the space science community directly involved in education at the pre-college level and in contributing to the broad public understanding of science.
- Develop a presence in every state in the U.S. to serve as a focal point for encouraging and assisting scientists and educators to develop partnerships and, in so doing, contribute in a meaningful way to space science education and outreach.
- Organize a comprehensive, national approach for providing information on and access to the results from space science education and outreach programs.
- Continue, and refine or enhance where appropriate, programs dedicated to the development and support of future scientists and engineers.
- Provide new opportunities for minority universities in particular and for underserved/underutilized groups in general to compete for and participate in space science missions and research programs.
- Develop the tools to evaluate the quality, effectiveness, and impact of space science education and outreach programs.

The Forums and Broker Facilitators will play a critical role in achieving these objectives.